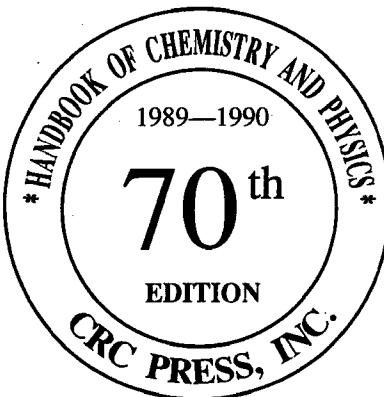


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$$15. \frac{d^2}{dx^2}[f(u)]$$

$$16. \frac{d^n}{dx^n}[uv] =$$

where $\binom{n}{r_1}$

$$17. \frac{du}{dx} = \frac{1}{\frac{dx}{du}}$$

$$18. \frac{d}{dx}(\log_a u)$$

$$19. \frac{d}{dx}(\log_e u)$$

$$20. \frac{d}{dx}(a^u) =$$

$$21. \frac{d}{dx}(e^u) =$$

$$22. \frac{d}{dx}(u^v) =$$

$$23. \frac{d}{dx}(\sin u)$$

$$24. \frac{d}{dx}(\cos u)$$

$$25. \frac{d}{dx}(\tan u)$$

$$26. \frac{d}{dx}(\cot u)$$

$$27. \frac{d}{dx}(\sec u)$$

$$28. \frac{d}{dx}(\csc u)$$

$$29. \frac{d}{dx}(\operatorname{ver} u)$$

$$30. \frac{d}{dx}(\operatorname{arc} u)$$

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CONVERSION FORMULAE FOR SOLUTIONS HAVING CONCENTRATIONS EXPRESSED IN VARIOUS WAYS

A = Weight per cent of solute
 B = Molecular weight of solvent
 E = Molecular weight of solute
 F = Grams of solute per liter of solution
 G = Molality
 M = Molarity
 N = Mole fraction
 R = Density of solution grams per cc

Concentration of solute SOUGHT	Concentration of solute GIVEN				
	A	N	G	M	F
A	—	$\frac{100N \times E}{N \times E + (1 - N)B}$	$\frac{100G \times E}{1000 + G \times E}$	$\frac{M \times E}{10R}$	$\frac{F}{10R}$
N	$\frac{A}{E}$	—	$\frac{B \times G}{B \times G + 1000}$	$\frac{B \times M}{M(B - E) + 1000R}$	$\frac{B \times F}{F(B - E) + 1000R \times E}$
G	$\frac{1000A}{E(100 - A)}$	$\frac{1000N}{B - N \times B}$	—	$\frac{1000M}{1000R - (M \times E)}$	$\frac{1000F}{E(1000R - F)}$
M	$\frac{10R \times A}{E}$	$\frac{1000R \times N}{N \times E + (1 - N)B}$	$\frac{1000R \times G}{1000 + E \times G}$	—	$\frac{F}{E}$
F	10AR	$\frac{1000R \times N \times E}{N \times E + (1 - N)B}$	$\frac{1000R \times G \times E}{1000 + E \times G}$	$M \times E$	—

ELECTROCHEMICAL SERIES

Petr Vanýsek

There are three tables for this Electrochemical Series. Each table lists standard reduction potentials, E° values, at 298.15 K (25°C), and at a pressure of 101.325 kPa (1 atm.). Table 1 is an alphabetical listing of the elements according to the symbols for the elements. Thus, data for Silver (Ag) precedes those for Aluminum (Al). Table 2 lists only those reduction reactions which have E° values positive to the potential of the Standard Hydrogen Electrode. In Table 2, the reactions are listed in the order of increasing positive potential and range from 0.000 V to +3.053 V. Table 3 lists only those reduction reactions which have E° values negative to the potential of the Standard Hydrogen Electrode. In Table 3, reactions are listed in the order of increasing negative potential and range from -0.017 to -4.10 V.

Table 1
ALPHABETICAL LISTING

Reaction	E°, V	Reaction	E°, V
$Ag^+ + e \rightleftharpoons Ag$	0.7996	$Ag_2WO_4 + 2 e \rightleftharpoons 2 Ag + WO_4^{2-}$	0.4660
$Ag^{2+} + e \rightleftharpoons Ag^+$	1.980	$Al^{3+} + 3 e \rightleftharpoons Al$	-1.662
$Ag(ac) + e \rightleftharpoons Ag + (ac)^-$	0.643	$H_2AlO_3^- + H_2O + 3 e \rightleftharpoons Al + 4 OH^-$	-2.33
$AgBr + e \rightleftharpoons Ag + Br^-$	0.07133	$AlF_6^{4-} + 3 e \rightleftharpoons Al + 6 F^-$	-2.069
$AgBrO_3 + e \rightleftharpoons Ag + BrO_3^-$	0.546	$As + 3H^+ + 3e \rightleftharpoons AsH_3$	-0.608
$Ag_2C_2O_4 + 2 e \rightleftharpoons 2 Ag + C_2O_4^{2-}$	0.4647	$As_2O_3 + 6 H^+ + 6 e \rightleftharpoons 2 As + 3 H_2O$	0.234
$AgCl + e \rightleftharpoons Ag + Cl^-$	0.22233	$HAsO_2 + 3 H^+ + 3 e \rightleftharpoons As + 2 H_2O$	0.248
$AgCN + e \rightleftharpoons Ag + CN^-$	-0.017	$AsO_2^- + 2 H_2O + 3 e \rightleftharpoons As + 4 OH^-$	-0.68
$Ag_2CO_3 + 2 e \rightleftharpoons 2 Ag + CO_3^{2-}$	0.47	$H_3AsO_4 + 2 H^+ + 2 e^- \rightleftharpoons HAsO_2 + 2 H_2O$	0.560
$Ag_2CrO_4 + 2 e \rightleftharpoons 2 Ag + CrO_4^{2-}$	0.4470	$AsO_4^{3-} + 2 H_2O + 2 e \rightleftharpoons AsO_2^- + 4 OH^-$	-0.71
$AgF + e \rightleftharpoons Ag + F^-$	0.779	$Au^+ + e \rightleftharpoons Au$	1.692
$Ag_4[Fe(CN)_6] + 4 e \rightleftharpoons 4 Ag + [Fe(CN)_6]^{4-}$	0.1478	$Au^{3+} + 2 e \rightleftharpoons Au^+$	1.401
$AgI + e \rightleftharpoons Ag + I^-$	-0.15224	$Au^{3+} + 3 e \rightleftharpoons Au$	1.498
$AgIO_3 + e \rightleftharpoons Ag + IO_3^-$	0.354	$AuBr_2^- + e \rightleftharpoons Au + 2 Br^-$	0.959
$Ag_2MoO_4 + 2 e \rightleftharpoons 2 Ag + MoO_4^{2-}$	0.4573	$AuBr_4^- + 3 e \rightleftharpoons Au + 4 Br^-$	0.854
$AgNO_2 + e \rightleftharpoons Ag + NO_2^-$	0.564	$AuCl_4^- + 3 e \rightleftharpoons Au + 4 Cl^-$	1.002
$Ag_2O + H_2O + 2 e \rightleftharpoons 2 Ag + 2 OH^-$	0.342	$Au(OH)_3 + 3 H^+ + 3 e \rightleftharpoons Au + 3 H_2O$	1.45
$Ag_2O_3 + H_2O + 2 e \rightleftharpoons 2 AgO + 2 OH^-$	0.739	$H_2BO_3^- + 5 H_2O + 8 e \rightleftharpoons BH_4^- + 8 OH^-$	-1.24
$2 AgO + H_2O + 2 e \rightleftharpoons Ag_2O + 2 OH^-$	0.607	$H_2BO_3^- + H_2O + 3 e \rightleftharpoons B + 4 OH^-$	-1.79
$AgOCN + e \rightleftharpoons Ag + OCN^-$	0.41	$H_3BO_3 + 3 H^+ + 3 e \rightleftharpoons B + 3 H_2O$	-0.8698
$Ag_2S + 2 e \rightleftharpoons 2 Ag + S^{2-}$	-0.691	$Ba^{2+} + 2 e \rightleftharpoons Ba$	-2.912
$Ag_2S + 2 H^+ + 2 e \rightleftharpoons 2 Ag + H_2S$	-0.0366	$Ba^{2+} + 2 e \rightleftharpoons Ba(Hg)$	-1.570
$AgSCN + e \rightleftharpoons Ag + SCN^-$	0.08951	$Ba(OH)_2 + 2 e \rightleftharpoons Ba + 2 OH^-$	-2.99
$Ag_2SeO_3 + 2 e \rightleftharpoons 2 Ag + SeO_4^{2-}$	0.3629	$Be^{2+} + 2 e \rightleftharpoons Be$	-1.847
$Ag_2SO_4 + 2 e \rightleftharpoons 2 Ag + SO_4^{2-}$	0.654	$Be_2O_3^{2-} + 3 H_2O + 4 e \rightleftharpoons 2 Be + 6 OH^-$	-2.63

Table 1 (continued)
ALPHABETICAL LISTING

Reaction	E°, V	Reaction	E°, V	Reaction
PbSO ₄ + 2 e ⇌ Pb(Hg) + SO ₄ ²⁻	-0.3505	Se + 2 H ⁺ + 2 e ⇌ H ₂ Se(aq)	-0.399	WO ₂ +
Pd ²⁺ + 2 e ⇌ Pd	0.951	H ₂ SeO ₃ + 4 H ⁺ + 4 e ⇌ Se + 3 H ₂ O	-0.74	WO ₃ +
[PdCl ₄] ²⁻ + 2 e ⇌ Pd + 4 Cl ⁻	0.591	SeO ₃ ²⁻ + 3 H ₂ O + 4 e ⇌ Se + 6 OH ⁻	-0.366	2 WO ₃
[PdCl ₆] ²⁻ + 2 e ⇌ [PdCl ₄] ²⁻ + 2 Cl ⁻	1.288	SeO ₄ ²⁻ + 4 H ⁺ + 2 e ⇌ H ₂ SeO ₃ + H ₂ O	1.151	Y ³⁺ +
Pd(OH) ₂ + 2 e ⇌ Pd + 2 OH ⁻	0.07	SeO ₄ ²⁻ + H ₂ O + 2 e ⇌ SeO ₃ ²⁻ + 2 OH ⁻	0.05	Zn ²⁺ +
Pt ²⁺ + 2 e ⇌ Pt	1.118	SiF ₆ ²⁻ + 4 e ⇌ Si + 6 F ⁻	-1.24	Zn ²⁺ +
[PtCl ₄] ²⁻ + 2 e ⇌ Pt + 4 Cl ⁻	0.755	SiO ₂ (quartz) + 4 H ⁺ + 4 e ⇌ Si + 2 H ₂ O	0.857	REI
[PtCl ₆] ²⁻ + 2 e ⇌ [PtCl ₄] ²⁻ + 2 Cl ⁻	0.68	SiO ₃ ²⁻ + 3 H ₂ O + 4 e ⇌ Si + 6 OH ⁻	-1.697	
Pt(OH) ₂ + 2 e ⇌ Pt + 2 OH ⁻	0.14	Sn ²⁺ + 2 e ⇌ Sn	-0.1375	
Pu ³⁺ + 3 e ⇌ Pu	-2.031	Sn ⁴⁺ + 2 e ⇌ Sn ²⁺	0.151	
Pu ⁴⁺ + e ⇌ Pu ³⁺	1.006	HSnO ₂ ⁻ + H ₂ O + 2 e ⇌ Sn + 3 OH ⁻	-0.909	
Pu ⁵⁺ + e ⇌ Pu ⁴⁺	1.099	Sn(OH) ₆ ²⁻ + 2 e ⇌ HSnO ₂ ⁻ + 3 OH ⁻ + H ₂ O	-0.93	
PuO ₂ (OH) ₂ + 2 H ⁺ + 2 e ⇌ Pu(OH) ₄	1.325	Sr ⁺ + e ⇌ Sr	-4.10	2 H ⁺ +
PuO ₂ (OH) ₂ + H ⁺ + e ⇌ PuO ₂ OH + H ₂ O	1.062	Sr ²⁺ + 2 e ⇌ Sr	-2.89	Cu ²⁺ +
Rb ⁺ + e ⇌ Rb	-2.98	Sr ²⁺ + 2 e ⇌ Sr(Hg)	-1.793	Ge ⁴⁺ +
Re ³⁺ + 3 e ⇌ Re	0.300	Sr(OH) ₂ + 2 e ⇌ Sr + 2 OH ⁻	-2.88	NO ₃ ⁻ +
ReO ₄ ⁻ + 4 H ⁺ + 3 e ⇌ ReO ₂ + 2 H ₂ O	0.510	Ta ₂ O ₅ + 10 H ⁺ + 10 e ⇌ 2 Ta + 5 H ₂ O	-0.750	Tl ₂ O ₃ +
ReO ₂ + 4 H ⁺ + 4 e ⇌ Re + 2 H ₂ O	0.2513	Tc ²⁺ + 2 e ⇌ Tc	0.400	SeO ₄ ²⁻ +
ReO ₄ ⁻ + 2 H ⁺ + e ⇌ ReO ₃ + H ₂ O	0.768	TcO ₄ ⁻ + 4 H ⁺ + 3 e ⇌ TcO ₂ + 2 H ₂ O	0.782	UO ₂ ²⁺ +
ReO ₄ ⁻ + 4 H ₂ O + 7 e ⇌ Re + 8 OH ⁻	-0.584	Te + 2 e ⇌ Te ²⁻	-1.143	Pd(OH) ₂
ReO ₄ ⁻ + 8 H ⁺ + 7 e ⇌ Re + 4 H ₂ O	0.368	Te + 2 H ⁺ + 2 e ⇌ H ₂ Te	-0.793	AgBr +
Rh ⁺ + e ⇌ Rh	0.600	Te ⁴⁺ + 4 e ⇌ Te	0.568	S ₄ O ₆ ²⁻ +
Rh ²⁺ + 2 e ⇌ Rh	0.600	TeO ₂ + 4 H ⁺ + 4 e ⇌ Te + 2 H ₂ O	0.593	AgSCN
Rh ³⁺ + 3 e ⇌ Rh	0.758	TeO ₃ ²⁻ + 3 H ₂ O + 4 e ⇌ Te + 6 OH ⁻	-0.57	N ₂ + 2
[RhCl ₆] ³⁻ + 3 e ⇌ Rh + 6 Cl ⁻	0.431	TeO ₄ ⁻ + 8 H ⁺ + 7 e ⇌ Te + 4 H ₂ O	0.472	HgO +
Ru ²⁺ + 2 e ⇌ Ru	0.455	H ₆ TeO ₆ + 2 H ⁺ + 2 e ⇌ TeO ₂ + 4 H ₂ O	1.02	Ir ₂ O ₃ +
Ru ³⁺ + e ⇌ Ru ²⁺	0.2487	Th ⁴⁺ + 4 e ⇌ Th	-1.899	2 NO +
RuO ₂ + 4 H ⁺ + 2 e ⇌ Ru ²⁺ + 2 H ₂ O	1.120	ThO ₂ + 4 H ⁺ + 4 e ⇌ Th + 2 H ₂ O	-1.789	[Co(NH ₂) ₆] ²⁺
RuO ₄ ⁻ + e ⇌ RuO ₄ ⁻	0.59	Th(OH) ₄ + 4 e ⇌ Th + 4 OH ⁻	-2.48	Hg ₂ O +
RuO ₄ + e ⇌ RuO ₄ ⁻	1.00	Ti ²⁺ + 2 e ⇌ Ti	-1.630	Ge ⁴⁺ +
S + 2 e ⇌ S ²⁻	-0.47627	Ti ³⁺ + e ⇌ Ti ²⁺	-0.368	Hg ₂ Br ₂
S + 2H ⁺ + 2 e ⇌ H ₂ S(aq)	0.142	TiO ₂ + 4 H ⁺ + 2 e ⇌ Ti ²⁺ + 2 H ₂ O	-0.502	Pt(OH) ₂
S + H ₂ O + 2 e ⇌ HS ⁻ + OH ⁻	-0.478	TiOH ³⁺ + H ⁺ + e ⇌ Ti ³⁺ + H ₂ O	-0.055	S + 2H
2 S + 2 e ⇌ S ₂ ²⁻	-0.42836	Tl ⁺ + e ⇌ Tl	-0.336	Np ⁴⁺ +
S ₂ O ₆ ²⁻ + 4 H ⁺ + 2 e ⇌ 2 H ₂ SO ₃	0.564	Tl ⁺ + e ⇌ Tl(Hg)	-0.3338	Ag ₄ [Fe(CN) ₆] ³⁻
S ₂ O ₈ ²⁻ + 2 e ⇌ 2 SO ₄ ²⁻	2.010	Tl ³⁺ + 2 e ⇌ Tl ⁺	1.252	IO ₃ ⁻ + 2
S ₂ O ₈ ²⁻ + 2 H ⁺ + 2 e ⇌ 2 HSO ₄ ⁻	2.123	TlBr + e ⇌ Tl + Br ⁻	-0.658	Mn(OH) ₂
S ₄ O ₆ ²⁻ + 2 e ⇌ 2 S ₂ O ₃ ²⁻	0.08	TlCl + e ⇌ Tl + Cl ⁻	-0.5568	2 NO ₂ ⁻ +
2 H ₂ SO ₃ + H ⁺ + 2 e ⇌ HS ₂ O ₄ ⁻ + 2 H ₂ O	-0.056	TlI + e ⇌ Tl + I ⁻	-0.752	Sn ⁴⁺ +
H ₂ SO ₃ + 4 H ⁺ + 4 e ⇌ S + 3 H ₂ O	0.449	Tl ₂ O ₃ + 3 H ₂ O + 4 e ⇌ 2 Tl ⁺ + 6 OH ⁻	0.02	Sb ₂ O ₃ ²⁻ +
2 SO ₃ ²⁻ + 2 H ₂ O + 2 e ⇌ S ₂ O ₄ ²⁻ + 4 OH ⁻	-1.12	TIOH + e ⇌ Tl + OH ⁻	-0.34	Cu ²⁺ +
2 SO ₃ ²⁻ + 3 H ₂ O + 4 e ⇌ S ₂ O ₃ ²⁻ + 6 OH ⁻	-0.571	Tl(OH) ₃ + 2 e ⇌ TlOH + 2 OH ⁻	-0.05	BiOCl +
SO ₄ ²⁻ + 4 H ⁺ + 2 e ⇌ H ₂ SO ₃ + H ₂ O	0.172	Tl ₂ SO ₄ + 2 e ⇌ Tl + SO ₄ ²⁻	-0.4360	Bi(Cl) ₄ ⁻
2 SO ₄ ²⁻ + 4 H ⁺ + 2 e ⇌ S ₂ O ₆ ²⁻ + H ₂ O	-0.22	U ³⁺ + 3 e ⇌ U	-1.798	Co(OH) ₃
SO ₄ ²⁻ + H ₂ O + 2 e ⇌ SO ₃ ²⁻ + 2 OH ⁻	-0.93	U ⁴⁺ + e ⇌ U ³⁺	-0.607	SO ₄ ²⁻ +
Sb + 3 H ⁺ + 3 e ⇌ SbH ₃	-0.510	UO ₂ ⁺ + 4 H ⁺ + e ⇌ U ⁴⁺ + 2 H ₂ O	0.612	SbO ⁺ +
Sb ₂ O ₃ + 6 H ⁺ + 6 e ⇌ 2 Sb + 3 H ₂ O	0.152	UO ₂ ²⁺ + e ⇌ UO ⁺ ₂	0.062	AgCl +
Sb ₂ O ₃ (senarmontite) + 4 H ⁺ + 4 e ⇌ Sb ₂ O ₃ + 2 H ₂ O	0.671	UO ₂ ²⁺ + 4 H ⁺ + 2 e ⇌ U ⁴⁺ + 2 H ₂ O	0.327	As ₂ O ₃ ²⁻ +
Sb ₂ O ₅ (valentinite) + 4 H ⁺ + 4 e ⇌ Sb ₂ O ₃ + 2 H ₂ O	0.649	UO ₂ ²⁺ + 4 H ⁺ + 6 e ⇌ U + 2 H ₂ O	-1.444	Calomel
Sb ₂ O ₅ + 6 H ⁺ + 4 e ⇌ 2 SbO ⁺ + 3 H ₂ O	0.581	V ²⁺ + 2 e ⇌ V	-1.175	Ge ²⁺ +
SbO ⁺ + 2 H ⁺ + 3 e ⇌ Sb + 2 H ₂ O	0.212	V ³⁺ + e ⇌ V ²⁺	-0.255	Calomel
SbO ₂ ⁻ + 2 H ₂ O + 3 e ⇌ Sb + 4 OH ⁻	-0.66	VO ²⁺ + 2 H ⁺ + e ⇌ V ³⁺ + H ₂ O	0.337	PbO ₂ +
SbO ₃ ⁻ + H ₂ O + 2 e ⇌ SbO ₂ ⁻ + 2 OH ⁻	-0.59	VO ²⁺ + 2 H ⁺ + e ⇌ VO ⁺ ₂ + H ₂ O	0.991	HAsO ₂ ⁻
Sc ³⁺ + 3 e ⇌ Sc	-2.077	V(OH) ₄ ⁻ + 2 H ⁺ + e ⇌ VO ²⁺ + 3 H ₂ O	1.00	Ru ³⁺ +
Se + 2 e ⇌ Se ²⁻	-0.924	V(OH) ₄ ⁻ + 4 H ⁺ + 5 e ⇌ V + 4 H ₂ O	-0.254	ReO ₂ +
		W ₂ O ₅ + 2 H ⁺ + 2 e ⇌ 2 WO ₂ + H ₂ O	-0.031	IO ₃ ⁻ + 3
				Hg ₂ Cl ₂ -
				Calomel
				Calomel